QUESTION BOX

Is a cast iron pipe when spongy acceptable if filled with cast iron cuttings and sal ammoniac? Has any member here had any experience in that direction?

MR. J. M. DIVEN: Our specifications for cast iron pipe distinctly prohibit that, but it is remarkable what an under specification water pipe will stand. At Troy, New York, a pipe laid in 1833 burst recently. It was the old style cast horizontally and uncoated pipe, cast in 9 foot lengths. A section of this pipe, not where it broke, was found to be a shade over $\frac{1}{8}$ inch thick. The pressure when the pipe burst was 60 pounds on a recording gage about two blocks from the location of the break. For nearly the entire length of the pipe the thickness on one side was about an eighth of an inch, most of the metal being on the other side of the pipe, probably the top side in casting, the core having settled some. Near the break, and where the pipe was not much thicker than the thinnest section, there were two drive ferrules less than 5 inches apart, but the pipe did not give out near them. That a pipe in its thin section only about one quarter the standard should hold so long sets us to wondering if we are not buying too much iron when we purchase standard pipe.

PRESIDENT HILL: The remarks just made by Mr. Diven are worthy of comment; that is, whether we are not paying for too much iron. There is a tendency in all water works to increase the pressure on the pipe lines as time goes on. Towns are frequently built in valleys, near to the water courses, so that as they build up and develop they extend out on the hills and it is necessary to introduce fire pressure or to separate service districts, and the tendency is to use more pressure on the pipe than the original design called for. Under these circumstances, the margin of safety is most useful. It is undoubtedly true that in all engineering structures we should play safe, and the factor of safety as it is called is usually from 5 to 10. It is to be expected, therefore, that any engineering struc-

ture will stand somewhat more than it was actually designed for, but, on the other hand, experience has shown that it is not safe to eliminate the factor of safety, that theoretical computations with regard to the strength of materials have certain limitations, and that all materials show variations in strength for which some provision has to be made. You may, as pointed out, have an extremely thin pipe which will stand pressures you would not have expected it to stand, but, on the other hand, you have no doubt had the experience many times of pipes bursting under pressures much lower than they were designed to stand. You have, therefore, to strike a happy average in order to get safe results.

MR. J. M. DIVEN: At Troy, New York, a consumer wanted high pressure at his place. His place was about 700 feet from the dividing valve between the high and low service. To accommodate him the high service was extended to his place. The pressure went up to 155 pounds, and at night to 165 pounds. The pipe is Class B, and stood the high pressure, no leaks occurring.

MR. E. E. DAVIS: Probably the speaker's experience runs about as far back as that of any man in the Association, having been in the department forty-three years, and having had all sorts of experiences. Of some Class A pipe working under 90 pounds pressure one burst, and when it was cut out it was found to be chip-cracked. In another case a 10-inch pipe that was laid in 1830 was tapped. The bottom of the pipe was $\frac{3}{4}$-inch thick and the top was less than $\frac{1}{8}$-inch thick; yet that had been working under a pressure varying from 60 pounds to 100 pounds. We used to have lots of trouble when we were using the compression hydrant. Since we adopted the gate hydrant we do not have that trouble. We had two lines laid down that were tested by the factory; in each of these there was a large break; one of them was on a centrifugal pump line, the other on the bottom of the river. The reason for those breaks was never found out. The man who manipulated the butterfly valve was accused of being responsible for the break, at least he was made to believe he had done it. You can not get a water-ram from a centrifugal pump, that is a physical impossibility; but with a plunger pump it is different, because the action of the pump varies.

MR. C. W. WILES: With referenee to cast-iron pipe, the speaker had a somewhat similar experience, to that which has been related,

some three years ago. This was a 16-inch line. A crack occurred on the side of the pipe, and was some 6 or 8 inches long, going around one side right in the middle of 16-inch pipe. The ground showed no evidence of its ever having been moved. It was laid in heavy clay soil, and the pipe could not have moved. The pipe opened up vertically. That is one of those peculiar things that happen to pipe that we never can explain the cause of.

MR. WIRT J. WILLS: Cast iron pipe works "in a mysterious way its wonders to perform." Here is a little occasion where it worked in a very peculiar way. A 36-inch trunk line broke about 4 feet from the spigot end. It happened to break right by a creek, so that the excess flow of water could easily be taken care of, and it did not tear up the street much. When we went to get at it, by some hook or crook, nobody knows how, it cracked directly in line, right straight along the bottom, so that we only had to cut off about 18 inches. The speaker is telling you this to show you that there is some hope for cast iron pipe. Most of the time it is the other way. That saved us six or eight hours' work.

MR. J. M. DIVEN: Speaking of saving time in cutting out pipe; the speaker broke out a 30-inch cracked pipe with dynamite. Three one-pound sticks of dynamite were used; broken up into $\frac{1}{4}$ to $\frac{1}{3}$ length pieces. These were "mud capped" along the pipe, that is secured in place with clay. All were fired together, using a battery. The pipe was thoroughly broken up, and several hours time saved. This was done on a built up street and no damage done. The only precaution taken was to ask the residents to open their windows. Some mud was scattered, but no iron.

QUESTION: Is there an automatic hydraulic working check valve for closing either way when a break takes place on a large water main?

MR. J. N. CHESTER: There are several of them.

MR. J. M. DIVEN: Do they work automatically in either direction?

MR. J. N. CHESTER: Yes, sir. They work just the same as a non-return valve that you put on a boiler. If a cap blows out, it closes

against the other boilers; or if a pipe bursts beyond the check valve between the boilers and the engine, it will close it. When the pressure lowers to a certain amount the other side of it, it will close.

If you will look in the catalogues of most of the steam specialty houses you will find such valves advertised. The speaker has recently received bids from two different concerns, on 20-inch valves which were purchased and installed and work all right.

The problem to be solved was a 20-inch rising main to a reservoir along a side hill suspected of contemplating a slide, which, if it occurred, would certainly sever the main and not only empty the reservoir, but do great damage to inhabitants and property below. We, therefore, wished to install some sort of a device near the reservoir that if the pressure was suddenly released below it would close against the backward discharge and still permit a flow through it in either direction under normal conditions. We had no trouble procuring prices on such a device, together with guarantees, which in the case of the one purchased we tried out.

Devices like the above are built so that they will close from a drop of pressure on either side and have been mainly developed by the requirements of large boiler plants, where the danger of shutdown from ruptures needs to be avoided in order to minimize losses from the shutdown of the entire plant.

QUESTION: What percentage of water pumped is unaccounted for after all meter readings, pump slippage, flat rates, fire protection and leaks are known, or carefully estimated?

MR. J. N. CHESTER: The speaker is not the man that asked that question, but it is the question that is worrying the Water Consumption Committee. In one water works in which the speaker is interested, we can account for not more than 40 per cent. Another plant accounts for 85 per cent. There are water works that produce results all the way between those two figures; but the complaint is that there are not enough authentic results or tabulated data on the subject that can be presented to rate-making bodies, who think we should account for 100 per cent. In another case a commission sent a man to a plant, where he found how much the pump counters showed delivered, and then divided the amount to be earned by the thousand gallons displacement, the result of which he reported to the commission, and they rendered a decision that the rate should

be 11 cents straight; if that decision had stood the plant would have been out about 50 per cent loss of revenue, because that plant was not accounting for over about 50 per cent of pump displacement. If we could get enough data tabulated to plot a curve, it would be of inestimable value in such cases.

The speaker would like to hear a pretty free discussion of this question; but he fears there are not many that can give definite figures, that is, who have taken the trouble to add up their meter readings at the end of the year, or have a master-meter, or figures showing delivery of the water through a pump, the slippage of which is absolutely known.

PRESIDENT HILL: The chair is interested to know about the case that you spoke of where 85 per cent was accounted for, as to whether it was obtained after a careful analysis; because that seems very high. Very few plants account for much over 75 or 80 per cent of the water actually delivered to the mains.

MR. J. N. CHESTER: Mr. Huy reports that he found plants within a certain radius around Buffalo that accounted for 91 to 92 per cent last year, and that one division of the plant went down to 83 per cent, or something like that.

PRESIDENT HILL: Was that made from actual measurement, or from some assumed pump slippage?

MR. J. N. CHESTER: They have master-meters and a record of all of the consumers' meters; but that is a very high result. Mr. Hawley of the Pennsylvania Water Company, the speaker believes, got above 85 per cent once, and then dropped below it. At Jefferson City, Missouri, under flat rates, allowing for the amount consumed by metered consumers, it went over 80 per cent. At Edgeworth, Pennsylvania, we have gas-engine driven triplex pumps and all consumers metered, and they are accounting for a little over 40 per cent and still we could not save enough in ten years to pay for a pitometer survey, if by so doing we could account for all, because our gas bill is small; but there are few consumers per mile. It supplies a suburban territory. Another thing, the pumps draw from driven wells, and when they start they sometimes run quite a little before they pick up the water, and the counter is counting just the

same in the meantime. There is doubtless a large percentage that goes in that way; but the rest of it must be air and leaks in the mains, or failure of the meters to record, or a great many other things. The speaker has found percentages varying from 40 to 92 per cent; but still has not enough of them to establish something really permanent and convincing.

MR. CHARLES W. SHERMAN: These notes relate to the experience of the town of Belmont, Massachusetts, where the writer is one of the water commissioners. This town is a suburb of Boston, a residential community of 8000 people, with no manufacturing, but where there is a considerable use of water by market gardeners. The water supply is obtained from the Metropolitan Water Works, and is metered at the town line, where it is furnished, into the distribution pipes. The distribution system consists of 31½ miles of main pipes 2 inches to 12 inches in diameter, and 14¾ miles of service pipes, with 1430 services. It has been fully metered since 1898. The daily consumption for 1915 averaged 52 gallons per capita.

Not only are all the services, including municipal buildings, supplied with meters, but there are meters on watering troughs, etc., and the water department furnishes a man and a meter to measure the water used for sewer flushing. In fact, practically all the water used is metered, except that drawn from fire hydrants for extinguishing fires.

The proportion of the water supplied, which has been thus accounted for, has been as follows:

	per cent
1908	67.2
1909	65.6
1910	58.5
1911	61.0
1912	62.3
1913	64.2
1914	71.9
1915	82.5

No definite data are available to indicate where the unaccounted water goes. In 1910, following the decrease in the proportion for which we could account, it was thought that there must be a considerable number of leaks in the main pipes, and great pains were taken to find such leaks. These efforts did not meet with much success. Some leaks were found, but none of much consequence, and as shown

by the percentages, the gain in the next three years amounted to only about 5 per cent. It was then concluded that greater care in looking after house meters might show a further gain. Previously they had received good ordinary care; they were supposed to be read monthly, and it was believed that a meter could not be stopped or in bad condition for any considerable period without discovery. However, beginning with 1914 a systematic following up of all meters was undertaken, and no meter was allowed to stay in service more than a certain limited time, without removal, testing and cleaning. This policy resulted in a gain of 7 per cent in the water accounted for in the first year, and a further gain of 11 per cent in the following year. How much further gain can be accomplished in this way we do not know, but we are inclined to believe that not over 10 to 15 per cent of the water supplied is lost through main pipe leaks, and it may be possible to account for between 85 and 88 per cent of all the water supplied.

In this connection it may be interesting to note that in 1915, in the high service district of Belmont, a section including about two miles of 6-inch and 8-inch pipe, on a portion of which the pressure exceeds 160 pounds per square inch, and 47 services the percentage of the water supplied which was metered to consumers, was 94.

MR. J. N. CHESTER: The trouble is to find plants that are thoroughly metered, that have master-meters, as the one mentioned by Mr. Sherman has. That is a contribution very valuable to our records.

The Springfield Company near Philadelphia is so metered, but the Water Consumption Committee has been unable to get the data from it.

MR. C. W. WILES: The speaker undertook to find out what water was getting away last fall. We have to take the pump records, and intend to put in a master-meter, to check them. The pump records, and then the meter readings for the year are taken. The sprinkling wagons are all metered; the city buildings are metered; about 72 per cent of the consumers are metered—all of the large ones. In the smaller services it is not considered that there is much loss as they are carefully and frequently inspected. There are only a few kitchen faucets or toilets that are not metered. In that way about 62 per cent was accounted for, but the speaker was so much surprised that

he appealed to Mr. Chester to know what the matter was. Of course, that loss of about 40 per cent was included in the fire protection. Our fires are not large, and there is very little water used for fires. It also could be accounted for by flushing hydrants. We have some dead ends, and also five or six water fountains, which have very small streams, but do not believe that on our main lines we have many leaks, as we have an excellent pipe system, and have never been able to detect very much of a leak on our pipe lines. Of course, the service lines do leak; but such leaks are taken care of within twenty-four hours, and we never allow water to run to waste. The allowance for fire service, flushing hydrants, horse troughs, fountains, and possible leaks, must be deducted from the 40 per cent unaccounted for water. Some engineers who have been consulted on the subject, thought that ought to take care of pretty nearly half of it; so that would leave us in the neighborhood of 20 per cent, or a little over, unaccounted for.

MR. WIRT J. WILLS: This is a subject that most water works people have given a great deal of thought to. The speaker has been working on it for a number of years, with some results. Last year, 1915, he went at it a little more particularly than ever before, and accounted for about 40 per cent of the water. Out of the other 60 per cent comes all the water that is furnished the city for fires and the street sprinkling. Memphis has 150 miles of streets to sprinkle all the time. Then there is water for sanitary purposes, flush-tanks, and all that sort of thing. The city is about 27 per cent metered; the balance on a flat rate. The pumping record shows that, ten years ago the daily average was 15,000,000 or 16,000,000 gallons. In 1915, with a population of at least 135,000 people, the average was less than 12,000,000 gallons a day. The use of a pitometer combined with very vigilant inspection in those five years has saved us a great deal. That inspection business has been carried to such an extent that sometimes they say the speaker is arbitrary; for instance, if one of our men who live down the street walks up from his place and fails to see a leak, and the speaker comes along afterward and finds that leak, he gets after that man and asks him why he did not report the leak. If he repeats that performance three times he loses his job. It may seem hard, but it saves a lot of water.

We found one 4-inch line running into a creek; the water had been running away there twenty years, and nobody knew it.

MR. HENRY P. BOHMANN: With the exception of the automatic sprinkler systems and the public drinking troughs and bubblers, all water in Milwaukee is metered, the pumpage being based on the displacement of the pump plungers. After allowing 5 per cent for pump slippage and 3 per cent for under registration of meters, there remains "unaccounted for" 12 per cent. The metered consumption is about 72 per cent, unmetered about 8 per cent. A very close estimate is made of the unmetered drinking troughs, by taking an average of 10 drinking troughs in different sections of the city, estimating the consumption by stop watch and pail measurement. The amount used for fire protection is obtained from the Fire Department. We are informed of the time each engine is operated at a fire, the rated capacity of each fire engine being known, and figure the pumpage 50 per cent of their rated capacity. The amount of water that is used for settling sewer trenches is estimated, and even the amount of water that is used for filling new water mains that are laid, is taken into consideration. Where mains are flushed, the time that the hydrant is open is kept track of, and the pressure at that particular point, so that we can figure out how much water is used for that purpose. After all our figures are in we find only 12 per cent unaccounted for. We have not been able to reduce this figure in the last three years. We can send our report in to any one who is interested in this subject, showing the amount of water used for domestic use, for industrial and municipal use; the exact quantities for each. The speaker has often wished that some of the other cities would do the same thing, so that we could make comparisons. Cleveland is about the only city that keeps a record of the amount that is actually pumped and accounted for.

We are installing Venturi meters at the pumping station so that in another year the question of slippage will not have to be estimated. We have put that at 5 per cent for the past three years.

PRESIDENT HILL: Have you made any comparison of your results with theoretical losses that were obtained from meters in service, say based on the tests that were made in Columbus, which were very fully published in the *Engineering Record*? Tests were made of new pipe carefully caulked and under the best supervision. There is a residual loss which can not be prevented. How close to that theoretical loss have you ever worked that out? How close to the theoretical have you come?

MR. H. P. BOHMANN: We have not worked it out that way. The statement has been frequently made that no water works is accounting for more than 75 per cent even where they buy their water by meter measurement and sell it by meter measurement; but we find that leaks in our distribution system are not of great importance. We have had mains in service thirty or forty years that have never developed a leak.

MR. FRANK C. KIMBALL: Speaking in a general way of a water works in New Jersey, where the water is bought by meter measurement, there are three supplies in the town, high, intermediate and low, each one of which has its own meter. There are about 39 miles of pipe in the place, and something over 2100 services. All the water is metered except about 15 services, and of course the fire uses, together with such water as is used for flushing mains. The quantity used for fire purposes is estimated by the time the hydrants are opened, the pressure, length of hose, etc. The amount used for flushing sewers is also periodically measured. When the mains are flushed a pressure gauge is put on the hydrant, and a record is kept of the time it is open, so that the water is practically measured.

The records for the first quarter of this year, after making the usual estimate for the 15 unmetered services, show within a fraction of 90 per cent accounted for, on the high service; on the low service practically 93 per cent and on the intermediate service, it was just a little under 81 per cent. The percentage accounted for on the system as a whole was 87.7 per cent. That is a case where the water is all measured that comes into the system and as near as can be told by metering substantially all services and estimating by the time, pressure, size of nozzles, etc., water used for fire purposes, as it goes out. This has been brought to that state by constant watching. Two years ago 75 to 80 per cent was accounted for. The pipe system has been followed up by a systematic investigation until various leaks have been found and repaired, and the record for the last year, 1915, was somewhere around 87 to 88 per cent accounted for. The three master-meters on the inlet pipes are read every week.

There is a large factory installation in that town supplied through some fourteen meters, which are read every week. Their use is more or less erratic. The sum of these fourteen meters is subtracted from the two master-meters supplying the pipes upon which they are located, and if the remaining uses of water do not, week by

week, show a fairly straight line of consumption investigation is made to find out what the trouble is. A year ago last January the consumption apparently increased very rapidly. The usual superficial examinations discovered nothing; and after a week or more of rather strenuous work, a gentleman living in a certain part of the town wanted to know what made the noise that he heard in his house. Just such noises as that were being searched for. Nothing was found in his place, but nearby there was quite a racket at a sewer manhole, and on going down into it there was found a stream of water running into the sewer about 16 feet below the street, very close to the bottom of the sewer. A main was found close by that, in settlement, had broken off vertically. This was repaired and the percentage of consumption accounted for jumped up to its usual level. These things are followed up through the use of the master-meters practically once a week; and the accounted for consumption is kept up to a point around 90 per cent, but it requires eternal vigilance to do it. This is about as near perfection as it can be, and formerly 75 or 80 per cent was satisfactory.

MR. C. W. WILES: Accounting for water used for fire purposes by measuring the speed of the engines was novel and interesting to the speaker. In Delaware, Ohio, we have a high pressure and do not use any engines; and have been trying to evolve some scheme to find out how much water we use at a fire. We have a pump that is running continuously; when we have a fire we start another pump. We run the fire pump at something over the rate of speed that the other pump runs for domestic use. We have instructed the engineers at the station to make an accurate record of the minutes that the fire pump is running, and are trying to see if we can not get from that some kind of data of the amount of water that is being used at fires. It is evident that the domestic use will be about the same; and the other extra pump will show the fire use.

MR. A. P. FOLWELL: In New York City every foreman hands in a report of the number of lines of hose laid; the time that the water was flowing through each line, and the size of the nozzle used. From these reports the amount of water used by the Fire Department can be calculated quite accurately.

MR. HENRY P. BOHMANN: In Milwaukee the practice is for the fire department to make a report of the hours and minutes that

each fire engine is operated at either a fire plug or fire cistern. For the information of the members of this association it may be stated that the amount of lake water used during 1915 was 13,000,000 gallons out of a total pumpage of 17,000,000 gallons. We also have four fire boats that pump river water into an independent pipe line. The amount of river water pumped by these four fire boats during 1915, was 12,000,000 gallons, making a total amount of water pumped for fire extinguishing purposes of 25,000,000 gallons, of which 13,000,000 gallons was domestic water from the distribution system of the water department.

MR. J. N. CHESTER: Will the gentlemen who have taken part in this discussion, when they revise their remarks, give us some tangible figures? The discussion by Mr. Sherman gives percentages throughout a number of years. This would be accepted as evidence, if given properly. Let all sent in be such that it may be tabulated in such a way that from it we can make up some aggregate figures.

PRESIDENT HILL: The New York high-pressure fire system is a closed system; and they have been keeping a record at the pumping station of the amount of water that they have to pump in order to keep the lines full.

MR. J. N. CHESTER: Baltimore has such a system. They have a direct acting pump which keeps the mains full.

PRESIDENT HILL: They have centrifugal pumps in New York. It occurred to the speaker that on a closed system like the New York high pressure system one could obtain an excellent index of the residual loss which might be reasonably expected through leakage in mains and an idea of the minimum loss to which one could hope to attain. Could we not get someone to contribute to this phase of the question?

MR. EDWARD S. COLE: In an excellent paper by Mr. E. G. Bradbury of Columbus, Ohio, published in the *New England Water Works Journal*, vol. xxviii, page 315, the author gives the results of leakage tests on new lines of pipe before connections were made, indicating a loss per mile per inch of diameter of 100 to 200 gallons daily. This, of course, allows nothing for leakage from service pipes.

The late Mr. Emil Kuichling estimated an average loss of 2500 to 3000 gallons daily per mile of main, based upon one drop per second per joint in the main, five drops per second for each hydrant or gate valve, and three drops per second for each house service pipe. The Kuichling estimate of 3000 gallons per day per mile is not too high in many cases. In an old system especially with inferior service pipes we find all rules will fail.

In regard to water accounted for; a well managed water works, practically 100 per cent metered should account for about 85 per cent of its supply. Total supply should always be determined accurately by master meters, and on the other hand, slip of service meters and unmetered use should be determined as closely as possible, but should not be over estimated in the effort to cover up a large discrepancy.

A MEMBER: The speaker has been deeply interested in this discussion and would like to give you the benefit of some of his experience. It is doubtful if any of you superintendents here will ever be able to come very close to the percentage of water that you are accounting for. Perhaps our municipality is a little different from others, because of the fact that we are under municipal ownership. The State Department of Agriculture, on account of an epidemic of glanders, ordered the discontinuance of the use of drinking fountains for horses. We found that that very materially assisted us in accounting for some water; that there was a great amount of water going to waste through these drinking fountains. The present mayor of our village said that he wanted those drinking fountains removed because they were an eyesore. In order to prevent them from being an eyesore they were converted into beautiful flower gardens; so that now they are "a thing of beauty and joy forever." Self-closing faucets have been placed on the outside of each trough, so that teamsters can water their horses by drawing water from those faucets.

We furnish water to the fire department. We have large streams of water going into the different lakes in the parks. We furnish water to all the municipal buildings and for street sprinkling; yet we cannot account for over 50 per cent of the amount of water that we are supposed to be pumping. The only way we can account for what we are pumping is by the strokes of our engine, which is a rather inaccurate method and which requires an allowance for slippage.

MR. FRANK C. KIMBALL: One reason for our getting the close registration reported is that within the last three years practically every domestic meter on the system, something over 2000 altogether, has been taken out, cleaned, recalibrated, and reset, or else new ones supplied in their place, It is quite evident that a large part of the unaccounted for water is due to the small domestic meters not registering properly. We all know that, as much as the consumer holds the opinion to the contrary, the individual or domestic meters register, as a rule, against the water department.

MR. J. M. DIVEN: That brings up a question which is apropos here as to the frequency with which meters should be tested or replaced. Some base the reply to this question on the amount of water which has passed through them; others on the time that they have been in place. Probably the character of the water has something to do with it. The question is, how frequently should meters be taken out or tested?

MR. C. W. WILES: All meters are tested to register a little below 100 per cent when they come from the factory; new meters do not register quite up to the amount of water passing through them; the manufacturers expect that they will run under. Of course, the longer they run the greater percentage of loss there is. In a plant with 5000 meters, it is a pretty safe estimate to figure the percentage of actual water passing through as under registered at 4 or 5 per cent. This arises from different causes, and also from the original cause that no meter is expected, when it leaves the manufacturer's hands, to measure quite up to 100 per cent. That explains unaccounted for water to some extent. It is not fair to figure the percentage on the amount of water that passes through the meter as shown on your books as being the exact amount of water which actually does pass.

MR. GEORGE HOUSTON: The amount of water accounted for through meters during the last year in the Kalamazoo plant was 415,000,000 gallons out of a total of 725,000,000 gallons pumped. That simply includes all metered water. Our city is 100 per cent metered, excepting street washing, sewers, watering troughs and drinking fountains which may be included in the water accounted for and which will add about 15 per cent to the total before mentioned. That makes the amount of water accounted for about 72 per cent.

MR. C. F. SCHULZ: Cleveland, Ohio, accounts for about 94 per cent. Of course, our method of figuring has been a little different. The discharge mains of all our pumps are metered with Venturi meters, which show on an average not over 1 per cent of pump slippage. However, in accounting for the water pumped we deduct 3 per cent from the pump plungers displacement to determine the water delivered to consumers, and call that 100 per cent. Besides Cleveland we are supplying about thirteen villages with water; we have about 950 miles of water mains with over 95,000 service connections, exclusive of village mains and services. About 99 per cent of all services are metered. The metered water accounts for 88 per cent of the water which we consider has been delivered by the pumps, after deducting 3 per cent for slip of pumps and calling that quantity, i.e., the quantity delivered by the pumps, 100 per cent. We keep a record of all the water used for putting out fires, which is not much over 40,000,000[1] gallons for the entire year, or half a day's consumption. We also keep an accurate record of the water used for settling trenches, flushing sewers and for flushing mains and for various other purposes; for instance, we have one gang that flushes dead end water mains continually throughout the year. In addition to that we have a few connections that are not metered; we also furnish unmetered water to public utility corporations for construction purposes. We assume that the quantity of unmetered water furnished for these various purposes amounts to less than 3 per cent of the total pumped. All these together amount to about 94 per cent of the total pumpage. We have tried to be honest with ourselves. We have no means of determining losses caused by overflowing of reservoir. Water in the reservoir sometimes overflows 3 or 4 inches. No doubt a great deal of unaccounted for water is lost in that way.

MR. W. F. WILCOX: Do you supply any public water, unmetered, to any of the thirteen villages supplied?

MR. C. F. SCHULZ: We have meters at the city boundary line. All the water supplied to villages goes through meters. We further require that all villages shall meter every service connection for their own protection to enable them to know just how much water they account for, and they do account for a large per cent of the quantity delivered to them.

[1] 40,770,000 in 1913; 51,154,000 in 1914; 74,566,000 in 1915.

PRESIDENT HILL: In view of this discussion, how are you going to justify yourself before courts for that unaccounted for 40 per cent, Mr. Chester?

MR. J. N. CHESTER: Answering Mr. Hill, we must face the facts as we find them. Mr. Schulz said that the Venturi meters showed a pump slip of 1 per cent, and then said he took off 3 per cent. He further says that all water is metered and that the service meters register 88 per cent of the water passing the master meters. Now, that would make it 86 per cent, would it not?

MR. C. F. SCHULZ: We account for 88 per cent. We allow 3 per cent for slip of meters. We deduct 3 per cent from the plunger displacement to give us the amount of water furnished to the city.

MR. J. N. CHESTER: What do the master meters show?

MR. C. F. SCHULZ: According to the Venturi meters which measure all the water which leaves the pumping station the pump slippage averages not much more than 1 per cent. We have considered the Venturi meter not as accurate as the plunger pump when it comes to measuring water, and have assumed a slippage of 3 per cent in the pumps; or, in other words that 97 per cent of the water that the plunger displacement indicated was actually delivered into the distribution system.

MR. J. N. CHESTER: Commissioner Pennypacker, of Pennsylvania, after listening recently to a line of such testimony as we have had here today, interrupted the witness by saying it reminded him of a story of how the Dutch in early Colonial days determined the weight of goods purchased from the Indians. He said they would fill up one side of the scales with the article to be weighed, and then put enough stones on the other side of the scales to balance, and then guess at the weight of the stones.

MR. W. F. WILCOX: When the speaker was discussing Mr. Chester's own paper he objected to "rule-of-thumb" methods. But our constant examinations in checking up different departments have shown us that a Venturi meter will vary 1 per cent as a minimum. If you get a Venturi meter of large size within 1 per cent of accuracy, you are unusually accurate. Now we find with our pumps, which are about of the same character, generally speaking, as those at Cleveland, that about 3.6 per cent is good average operating condi-

tions. Probably Mr. Schulz is an operating engineer and has used his experience when he got that 3 per cent; therefore Mr. Chester should object to a "rule-of-thumb" method in arriving at that 3 per cent. Mr. Schulz takes the reading of every one of the service meters and they are added up exactly like a cash balance and are balanced against the Venturi meters. Mr. Chester must get back on the platform that he was on yesterday, and use scientific determinations, and not try to question Mr. Schulz by "rule-of-thumb".

MR. J. N. CHESTER: The "rule-of-thumb" method is just exactly the objection. Mr. Schulz does not say whether he has added or subtracted 3 per cent.

MR. W. F. WILCOX: You are trying to figure in both interest and discount. That is begging the question. Mr. Schulz has accounted for 85 per cent, and 3 per cent slip. The other 12 per cent is accounted for as loss. They have arrived at it by scientific research; they have taken the readings of each one of the little meters and added them up, as you would your nickels and dimes, and they have struck a cash balance; and you cannot come here with any "rule-of-thumb" and question that statement.

MR. C. F. SCHULZ: The speaker's statement was perhaps confusing, because we deducted the pump slippage and then called the balance 100 per cent. Mr. Wilcox has stated very correctly that if we do not deduct for slip then we account for 85 per cent of plunger displacement.

MR. J. N. CHESTER: You know absolutely that 85 per cent is right, for you have that. Now, you started with 94 per cent; and your method of arriving at the difference between 85 and 94 is a sort of "rule-of-thumb," is it not?

MR. C. F. SCHULZ: Before we determined the amount of water used for putting out fires, for flushing sewers, and for filling trenches, we put meters on the fire hydrants, so as to get the rate of flow per hour. Then an accurate record was made of the time that each hydrant was used for any purpose. Of course, there will be some variation; but as stated before, we don't make any secret of how we arrive at those results.

The following table shows the percentage of water used for various purposes and the percentage unaccounted for during the years 1913, 1914 and 1915.

	1913	1914	1915
Nominal pumpage during the year	27,099,632,872	29,803,485,871	28,557,394,916
Slippage through pumps estimated @ 3 per cent	812,988,986	894,104,576	856,721,847
Total consumption to be accounted for, gallons	26,286,643,886	28,909,381,295	27,700,673,069
Total consumption to be accounted for, per cent	100	100	100
Metered and sold	82.98	78.57	82.03%
Metered but free	5.72	6.32	6.74
Total registered by meters	88.70	84.89	88.77
Slip of meters, estimated @ 3 per cent	2.66	2.55	2.66
Total water passing through meters	91.36	87.44	91.43
Estimated use of water by those paying on assessment basis*	0.045	0.01	0.003
Hydrant rentals*	0.12	0.11	0.144
Building purposes*	0.17	0.21	0.369
Sprinkling streets*	0.107	0.03	0.024
Estimated consumption for miscellaneous purposes not covered by hydrant rentals, building permits, etc.*	0.36	0.33	0.180
Unmetered free water for testing meters, building sewers, paving streets, puddling trenches, flushing water mains, flushing sewers, watering troughs, parks and fountains, fire extinguishment, etc	2.45	1.94	2.07
	94.61	90.07	94.17
Leakage from pipe system†	1.10	1.40	1.20
Total accounted for	95.71	91.47	95.37
Unaccounted for	4.29	8.53	4.63

* Estimated consumption for the purposes mentioned was determined by calculating the quantity of water that the money received on the assessment basis would pay for at the uniform metered water rate of 5⅓ cents per thousand gallons. The actual quantity used for these purposes and the quantity wasted no doubt greatly exceed this estimate.

† Based on reports of leaks discovered by the waste detections department. No data as to duration of leaks. Data not reliable.

MR. NICHOLAS S. HILL, JR.: It is very gratifying to see so many water works men who are earnestly desirous of determining the actual distribution of the water which they pump, and the example of those gentlemen who have spoken today is one that should be emulated by all. On the other hand, before the preceding discussion goes on final record, there should be some modifying statement or the greatest injustice will be done to many water companies.

There are few plants which, from the speaker's experience, can show anything like the results which have been indicated here today by two or three of the gentlemen who have spoken. Now, what would be the outcome if we let these results go on the record as a standard? A great many water works will be done a gross injustice in establishing a rate scale. There may be some here who would not seriously object to that, but all fair minded men will realize that even a water company is entitled to its just dues. An injustice is done even to municipal plants by expecting too high a standard, so that this discussion may act as a boomerang on the superintendent of a municipal plant who will be called to task when he cannot account for as high a percentage of water as has been indicated by some of the speakers. A plant which is accounting for 80 per cent of the water pumped is a most efficient plant. Statistics would probably show that the vast majority of plants in operation today are not accounting for 70 per cent of the water pumped, some may fall below 60 per cent.

It may be well for the sake of accumulating data of this kind to summarize some of the things which must be taken into consideration if those who are present today go home and endeavor to get some data together relative to their plants. In order that these data may be useful for practical purposes, certain things must be taken into consideration. First, the speaker suggests the advisability of our Committee on Water Consumption preparing a blank, if they have not already done so, and that they send it to all the superintendents who are represented in the Association, outlining those elements which should be taken into consideration in order to obtain accurate and definite results. For instance, before a determination of the water consumed may be made, actual determinations of the pump slippage must be made. You cannot guess it. Pumps in one of the large pumping stations of the City of New York, which were supposed to be in good shape, showed 63.5 per cent slip. If that condition can exist with a high class pump in a large station,

will it not also be found in smaller water works? The high slippage mentioned was not due to plunger slippage, but to defective valves. The only way to determine pump slippage accurately is by volumetric measurement through the agency of a reservoir of known dimensions, by using a pitometer, Venturi, or some other equally accurate way. It is absolutely useless to make reports on systems that are partially metered and upon which estimates have to be made of the water consumed. Such estimates are nothing more than wild guesses. It is necessary that at least 80 per cent of the taps be metered in order that any estimate of the water accounted for may be reasonably accurate. On any metered system you must have records by which the total registration of meters for household, manufacturing and other purposes may be easily and quickly tabulated, so that your results are accurate in the end. Meters should be placed on all public buildings, sewer flushing connections, and other taps where water is supplied free. Otherwise, these losses will distort the result. It is also advisable to keep some record of the average acccuracy of meters removed from service after a reasonable period of time, so that the slippage of the individual meter may be determined. After all these elements have been taken into account, you still have to provide for the water used for fire purposes, which cannot be metered.

The speaker wants particularly to dwell on the water used for sewer flushing. He does not carry figures in his head, but does know that in several instances where he has had the opportunity to make actual measurements of water consumed by flush tanks, he has found that it is about 100 per cent more than it is usually estimated to be. You cannot make any rational estimate of the water accounted for unless you have an accurate record of the water which goes for sewer flushing. Now, after all of the precautions above indicated have been taken, it seems that the data should be set up in standard form, and there should be copious notes with regard to the characteristics of the system. It is useless to expect a system with a low consumption per mile of main to show as low a percentage of leakage as a system which has a large consumption per mile of main. This is one of the characteristics which make a great deal of difference in the results which may be expected.

Then there is the question of reservoirs. A great many plants have reservoirs which are unlined. It is necessary to make some experiments on such reservoirs to determine what the average losses

from seepage amount to. These losses must be taken into consideration before the losses from the distribution system can be accurately determined.

MR. W. F. WILCOX: At the Cincinnati meeting the speaker discussed this same question, and made this point then, and has looked into the question since, and sees no reason to change his opinion; that a water works which could account for only 65 per cent of the water was poor management; that 70 per cent was fair management; that 75 per cent was good management; that 80 per cent was excellent management; that 85 per cent was so very excellent that it needed to be questioned. Now, to recite some cases as for instance Cleveland, where Professor Bemis had stated that he accounted for 85 per cent; and according to information from men who have studied this question for years, 85 per cent seemed so uncommonly large that it called for investigation, not questioning the personal veracity of men of such high standing as Schulz and Bemis, but it left the rest of the water works people far in the shade.

Now any of the large meters will measure water within 1 per cent. A meter measuring an output say up to 1,000,000 gallons per day will cost $500 to install. That amount will hold up to a 25,000,000 gallon capacity meter, which will cost about $150 per 1,000,000 gallons capacity. There is no plant anywhere, no matter how poor and miserable and little it be, that can not afford to buy a $500 meter, because it will save them $500 worth of coal in two years, at the minimum. Mr. Schulz has stated that he supplies thirteen villages and that those villages take care of their own minor losses. That helped out the city showing, how many per cent it would be hard to say.

Another thing, a leak in a large town will seem infinitesimal, in a big plant like Cleveland for instance, whereas it might have considerable effect in a town pumping 500,000 or 1,000,000 gallons per day. When you compare a small plant to a big plant, leakages in mains and valves are absorbed very rapidly in the latter, but materially affect the small plant. You will remember the speaker outlined to you yesterday, in giving you a few little "rules-of-thumb", that the cost of operating a boiler plant, outside of the fuel, ran from $3 per b.h.p. down to 50 cents or maybe to 25 cents, depending on the size of the plant; and leakage percentages vary in the same general ratio. That may not be mathematically correct, but speaking

generally, a small plant can never hope to get as large a percentage of accounted for water as the big plants do. The small plants have been entirely too careless in not metering their output. It is the speaker's belief that any man that will buy a good meter of any of the several standard makes will save the cost of that meter, at the maximum, in two years. On a test it was shown that one valve on a 12,000,000 gallon pump made a leakage of 5 per cent; and there were 1564 valves in two pumps.

MR. FRANK C. KIMBALL: What our President says with regard to allowing this Association to go on record as saying that these large percentages of water accounted for can not be obtained in all cases is pertinent; because they cannot as a rule. In saying that the Summit works were accounting for practically 90 per cent it was particularly stated that weekly comparisons were made to be sure that the normal consumption was not exceeded during any given period. Six other municipalities in New Jersey are supplied with water by this company, and are supplied from two pumping stations, where the usual method of measuring the output are employed, namely, by the plunger displacement. There is an allowance of 5 per cent for slip in pumps. Of those six municipalities four are entirely metered, the other two are to an extent that makes the entire six average about 85 or 90 per cent metered; and after allowing 5 per cent slip of pumps a trifle under 80 per cent of the water was accounted for. That is the other side of the question. One reason for being a little more particular in the first instance mentioned is that the price per million gallons for the water purchased through master-meters is high. The difference there is apparent in dollars. When pumping the water the cost is not quite so apt to be noticed. It is not at all certain judging from the character and performance of the pumping plants, that the slippage does not exceed 5 per cent. With some thirty years' experience in operating water works plants, most of them pumping systems, the speaker believes that with all the care that can economically be used the average accounted for water should not be considered as over 80 per cent, and that it is under exceptionally favorable conditions, or under something more than usual good management, when it is maintained higher than that.

MR. JAMES B. WILSON: What precaution can be taken to care for mains laid through salt marshes or creeks where chemical action has

the same effect upon the main as electrolysis? The speaker has removed over 3000 feet of main, or abandoned it, in the past two years on account of such action.

MR. DANIEL D. JACKSON: We have had considerable experience with regard to electrolysis affecting water pipe and the chemical action of acid clay on water pipe, in the Department of Water Supply of New York City. In analyzing those pipes which have been acted on by electrolysis from currents escaping from street railway lines, and those pipes which have been acted on undoubtedly by the chemical action of clays, we could find no differences at all in the appearance of the pipe itself. They were both very soft and could be readily cut with a knife, and the material left over was nearly all carbon, the carbon in the pipe being left over, and the iron being dissolved. Therefore, there is no means of determining what caused it from the chemical analysis alone, but only from examination of the conditions in that locality. And in those places where the conditions evidently show that it was the action of the soil, and not stray currents, the remedy is to have the pipe filled around with sand, so that the clay does not come in direct contact with the pipe. In this way all trouble from this source is largely if not entirely eliminated.

MR. J. N. CHESTER: If Mr. Wilson will go down to Atlantic City and talk to the officials there, and look at their pipe graveyard, he will get further information. They have laid pipe there across salt marshes. Without wishing to discount Doctor Jackson's information at all, there are some startling things that can be seen there of what happens to cast iron pipe. They tried both wooden and steel pipe, and have recently resorted to cast iron pipe laid on concrete piers supporting it above ground and tide. Their experience is worthy of note and study.

MR. DANIEL D. JACKSON: There is no question that the action is greatest in salt marshes. Where pipe has to go through practically salt water, sand itself is not sufficient. In such cases the pipe must be coated with tar or asphalt, and covered with concrete.